

Please type a plus sign (+) inside this box → ☐

PTO/SB/05 (08-00)  
Approved for use through 10/31/2002. OMB 0651-0032  
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

# UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.

First Inventor

Kluft, W.

Title

Method/Device...Parameters....

Express Mail Label No.

## APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. ☒ Fee Transmittal Form (e.g., PTO/SB/17)  
(Submit an original and a duplicate for fee processing)
2. ☒ Applicant claims small entity status.  
See 37 CFR 1.27.
3. ☒ Specification [Total Pages ☐ 15 ]  
(preferred arrangement set forth below)
  - Descriptive title of the invention
  - Cross Reference to Related Applications
  - Statement Regarding Fed sponsored R & D
  - Reference to sequence listing, a table, or a computer program listing appendix
  - Background of the Invention
  - Brief Summary of the Invention
  - Brief Description of the Drawings (if filed)
  - Detailed Description
  - Claim(s)
  - Abstract of the Disclosure
4. ☒ Drawing(s) (35 U.S.C. 113) [ Total Sheets ☐ 4 ]
5. Oath or Declaration [ Total Pages ☐ 2 ]
  - a. ☒ Newly executed (original or copy)  
Copy from a prior application (37 CFR 1.63 (d))  
(for continuation/divisional with Box 17 completed)
  - b. ☐ DELETION OF INVENTOR(S)  
Signed statement attached deleting inventor(s)  
named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
6. ☐ Application Data Sheet. See 37 CFR 1.76

## ADDRESS TO:

Assistant Commissioner for Patents  
Box Patent Application  
Washington, DC 20231

7. ☐ CD-ROM or CD-R in duplicate, large table or Computer Program (Appendix)
8. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
  - a. ☐ Computer Readable Form (CRF)
  - b. Specification Sequence Listing on:
    - i. ☐ CD-ROM or CD-R (2 copies); or
    - ii. ☐ paper
  - c. ☐ Statements verifying identity of above copies

## ACCOMPANYING APPLICATION PARTS

9. ☐ Assignment Papers (cover sheet & document(s))
10. ☐ 37 CFR 3.73(b) Statement (when there is an assignee) ☐ Power of Attorney
11. ☐ English Translation Document (if applicable)
12. ☒ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
13. ☐ Preliminary Amendment
14. ☒ Return Receipt Postcard (MPEP 503) (Should be specifically itemized)
15. ☐ Certified Copy of Priority Document(s) (if foreign priority is claimed)
16. ☐ Other: .....

17. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment, or in an Application Data Sheet under 37 CFR 1.76:

☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP)

of prior application No.: \_\_\_\_\_

Prior application information:

Examiner \_\_\_\_\_

Group / Art Unit: \_\_\_\_\_

For CONTINUATION OR DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 5b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

## 18. CORRESPONDENCE ADDRESS

☐ Customer Number or Bar Code Label



or

☐ Correspondence address below

Name

Vincent L. Ramik, Esquire

Address

7345 McWhorter Place; Suite 101

City

Annandale

State

Virginia

Zip Code

22003

Country

USA

Telephone

703 642 5705

Fax

703 6422117

Name (Print/Type)

Vincent L. Ramik

Registration No. (Attorney/Agent)

20,663

Signature

Date 11/9/00

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

**FEE TRANSMITTAL  
for FY 2001**

Patent fees are subject to annual revision.

**Complete if Known**

Application Number	
Filing Date	November 9, 2000
First Named Inventor	Kluft, W.
Examiner Name	
Group Art Unit	
Attorney Docket No.	

**TOTAL AMOUNT OF PAYMENT** (\$) 373.00**METHOD OF PAYMENT**

- 1.
- ☒
- The Commissioner is hereby authorized to charge indicated fees and credit any overpayments to:

Deposit Account Number 08-0145

Deposit Account Name Vincent L. Ramik

- ☒
- Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17

☐ Applicant claims small entity status. See 37 CFR 1.27

- 2.
- ☒
- Payment Enclosed:**

☒ Check ☐ Credit card ☐ Money Order ☐ Other**FEE CALCULATION****1. BASIC FILING FEE**

Large Entity	Small Entity	Fee Code (\$)	Fee Code (\$)	Fee Description	Fee Paid
--------------	--------------	---------------	---------------	-----------------	----------

101	710	201	355	Utility filing fee	\$355
106	320	206	160	Design filing fee	
107	490	207	245	Plant filing fee	
108	710	208	355	Reissue filing fee	
114	150	214	75	Provisional filing fee	

**SUBTOTAL (1)** (\$) 355.00**2. EXTRA CLAIM FEES**

Total Claims	Extra Claims	Fee from below	Fee Paid
22	-20** = 2	\$9	\$18
2	-3** = 0		0
Multiple Dependent			0

Large Entity	Small Entity	Fee Code (\$)	Fee Code (\$)	Fee Description	Fee Paid
--------------	--------------	---------------	---------------	-----------------	----------

103	18	203	9	Claims in excess of 20	
102	80	202	40	Independent claims in excess of 3	
104	270	204	135	Multiple dependent claim, if not paid	
109	80	209	40	** Reissue independent claims over original patent	
110	18	210	9	** Reissue claims in excess of 20 and over original patent	

**SUBTOTAL (2)** (\$) 18.00

\*\*or number previously paid, if greater; For Reissues, see above


**FEE CALCULATION (continued)****3. ADDITIONAL FEES**

Large Entity	Small Entity	Fee Code (\$)	Fee Code (\$)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for <i>ex parte</i> reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for reply within first month	
116	390	216	195	Extension for reply within second month	
117	890	217	445	Extension for reply within third month	
118	1,390	218	695	Extension for reply within fourth month	
128	1,890	228	945	Extension for reply within fifth month	
119	310	219	155	Notice of Appeal	
120	310	220	155	Filing a brief in support of an appeal	
121	270	221	135	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive - unavoidable	
141	1,240	241	620	Petition to revive - unintentional	
142	1,240	242	620	Utility issue fee (or reissue)	
143	440	243	220	Design issue fee	
144	600	244	300	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
126	240	126	240	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	
146	710	246	355	Filing a submission after final rejection (37 CFR § 1.129(a))	
149	710	249	355	For each additional invention to be examined (37 CFR § 1.129(b))	
179	710	279	355	Request for Continued Examination (RCE)	
169	900	169	900	Request for expedited examination of a design application	

Other fee (specify) \_\_\_\_\_

\*Reduced by Basic Filing Fee Paid

**SUBTOTAL (3)** (\$) 0**SUBMITTED BY**

Name (Print/Type)	Vincent L. Ramik	Registration No. (Attorney/Agent)	20,663	Telephone	703 642 5705
Signature		Date	11/9/00		

**WARNING:** Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

005077 09980260

## TITLE OF THE INVENTION

Method and device for measuring process parameters of a material working process

## BACKGROUND OF THE INVENTION

The present invention relates to a method and a device for measuring process parameters of a material working process.

High energy beams, in particular laser beams, are used in different ways for material working purposes, for example for cutting, boring and welding different types of material and workpiece geometries. What is common to all processes is that prior to the working process the workpiece is melted and/or partially vaporized. Conversion of the material to be worked into different states of aggregation frequently leads to material defects and process changes during material working. In particular processes during which the material passes through all three states of aggregation, namely the solid, liquid and vapourous states of aggregation, are influenced by a plurality of process parameters.

Below the process parameters influencing the weld geometry during laser welding are stated by way of example:

- Weld preparation:  
for example edge preparation, material pairing, type of joint
- Process control:  
for example employment of an additional wire, rate of feed, inert and operating gas

- Properties of the working means:  
for example guiding of the laser beam, optical focusing device, reproducibility of weld track
- Process parameters of the laser means:  
for example laser performance, stability of laser performance, beam quality

Further, the development in the automobile sector necessitates more and more complex working geometries which require guidance of the high energy radiation.

To guarantee reproducible working quality, on-line monitoring of the working process is required during which the relevant process parameters are measured and used for controlling the material working process.

From DE 197 41 329 C a method and a device for metal working using plasma-induced high energy radiation is known where the area of the vapour capillaries is monitored for example by a CCD camera for the purpose of controlling and monitoring the working process. In this connection it is envisaged to monitor the area of the vapour capillaries at at least two measuring points to obtain different capillary geometry sizes. Specific areas of the picture taken by the CCD camera are evaluated for determining the capillary geometry sizes. Since all picture data must be transmitted to the evaluation means first, measurement at high monitoring frequency is not possible. Further, the known process does not allow the vapour capillary environment to be monitored such that further independent monitoring and control systems are required for optimized process control.

It is the object of the present invention to provide a method and a device of the aforementioned type for simultaneously acquiring a plurality of process parameters at a high monitoring frequency using a single monitoring means.

## SUMMARY OF THE INVENTION

The present invention advantageously provides an optical sensor having a dynamic range of more than 70 dB. Such a sensor is capable of simultaneously sensing the area of the vapour capillaries, the melting zone surrounding the vapour capillaries and possibly also a border zone surrounding the melting zone, and allows the measuring signals to be evaluated despite the high contrast range of the picture produced. This allows measuring signals from different sections of the picture field to be simultaneously evaluated for the purpose of determining the process parameters. Since only the measuring signals of sections of the picture field are transmitted to the evaluation means a high monitoring frequency of more than 1 kHz is attainable as the amount of measuring signal data used for evaluation purposes is kept small.

In the picture field sensed by the optical sensor preferably different freely selectable picture sections are defined with exclusively the measuring signals of these picture sections being simultaneously evaluated for the purpose of determining different process parameters which are to be monitored.

Free selection of the picture sections allows a maximum of flexibility with regard to configuration of a monitoring system. Monitoring of specific areas of the melting zone is of importance insofar as the molten mass is fed from the hotter region around the vapour capillaries to the more distant end of the melting zone. Here said molten mass cools down and solidifies. Obviously the hot material is transported at irregular intervals, which affects solidification of the molten mass and may lead to discontinuities and defects in the weld. Thus monitoring of the solidification front at the end of the melting zone is essential with regard to detection of defects occurring in connection with material solidification, for example surface roughness, weld convexity, holes, surface pores etc. Detection of such defects would not be possible by monitoring the vapour capillaries alone.

Measuring signals of picture sections showing the area of the melting zone in front of and at the side of the vapour capillaries may be used for detecting defects occurring during weld preparation.

Measuring signals of picture sections showing the area of the melting zone upstream of the working zone, as seen in the working direction, or the border zone upstream of the melting zone may be used for measuring the weld location and for controlling the laser position or workpiece position. A combination of capillary monitoring, weld zone monitoring and weld tracking offer the user the advantage that all monitoring and control functions can be performed with a single monitoring and control system, which also facilitates operation of the control unit.

The penetration depth of the high energy beam can be determined from a reduced number of pixels of a picture section showing the center of the vapour capillaries.

The measuring signals of a picture section showing the melting zone downstream of the vapour capillaries, as seen in the working direction, and/or a border area downstream of the melting zone, as seen in the working direction, may be used for measuring the surface topography of the workpiece subjected to the working process.

For special monitoring tasks it is possible to provide a filter in addition to the optical sensor in the beam path such that light with predetermined wavelengths can be filtered.

A CMOS camera is preferably used as optical sensor. The CMOS technology allows pixels of the picture field to be evaluated independently of the overall picture whereby the amount of measuring signal data can be advantageously reduced to a minimum. It is not necessary to acquire all measuring signal data first and then to selectively evaluate them. In this way a high monitoring frequency of more than 1 kHz is attainable.

For this purpose preferably an optical sensor having a dynamic range of more than 100 dB is used.

The focal position of the high energy beam can be determined by measuring the change in light intensity in a linear or rectangular picture section which linearly extends through the vapour capillaries and the two neighboring melting zones.

### BRIEF DESCRIPTION OF THE DRAWINGS

Hereunder embodiments of the present invention are explained in detail with reference to the drawings in which:

- Fig. 1 shows a diagrammatic representation of a device according to the invention,
- Fig. 2 shows the picture field produced by a CMOS camera showing selected picture sections,
- Fig. 3 shows an example of determination of the focal position of a laser light beam, and
- Fig. 4 shows examples of different working defects.

### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 shows the working of a metal workpiece 8 using a laser beam 2 which is focused onto the workpiece 8 with the aid of a reflecting mirror 4 and a focusing mirror 6. A CMOS camera 10 having an optical device 12 is arranged above the focusing mirror 6, the camera monitoring the working zone of the

workpiece 8 coaxially to the focused laser light beam 2 via the focusing mirror 6. For this purpose the focusing mirror 6 may be provided with a corresponding perforation which allows passage of the beam or may be at least partially transparent to the monitored light wavelengths. The drawing diagrammatically shows a measuring beam 3 within a measuring cone 5 of the CMOS camera 10, the measuring beam 3 sensing vapour capillaries 14 in the workpiece 8 with regard to the emitted light intensity. Said vapour capillaries 14 are produced by heating and vaporization of the workpiece 8 material and form a deepened portion in the workpiece 8, whose capillary geometry size values are evaluated with the aid of the CMOS camera 10 and an evaluation device 18 for the purpose of process control. Beyond the beam 3 path the measuring cone 5 of the CMOS camera 10 senses, prior to the working process and in the area of the weld 17, a picture field which does not only show the vapour capillaries 14 but also the melting zone 20 surrounding the vapour capillaries 14 and a border zone beyond the melting zone 20. The plasma cloud 31 shown in Fig. 1 is transparent for the purpose of the envisaged measurements.

As can be seen from Fig. 1 it is assumed in the diagrammatic representation that the workpiece 8 is moved relatively to the high energy beam 2 in the direction indicated by an arrow. Of course, the workpiece 8 may also be stationary and moved into the means for producing high energy beams, for example a laser means.

Between the CMOS camera 10 and the focusing mirror 6 a filter 15 may be arranged if certain light wavelengths are to be excluded from the measurement.

The CMOS camera 10 has a dynamic range of approximately 120 dB such that both the gaseous phase and the melting phase and possibly also the solid phase of the workpiece 8 can be simultaneously monitored and measured during the working process.



The CMOS technology allows individual pixles to be evaluated independently of the overall information of the picture field such that only certain freely selectable picture sections within the picture field scanned by the camera and of the picture produced by the camera 10 are transmitted to the evaluation means 18 for evaluation purposes. For on-line determination and evaluation of all process variables required for monitoring and control at a monitoring frequency of at least 1 kHz a data reduction is performed. This is done on the basis of specific features which are characteristic of the corresponding process variables.

For example, the penetration depth of the laser beam 2 entering the workpiece 8 can be determined on the basis of a few pixles, the radiation from the center of the vapour capillaries 14 being projected to said pixles.

Fig. 2 shows the picture field monitored by the CMOS camera 10 including the area of the vapour capillaries 14, the area of the melting zone 20 and the border area surrounding the melting zone 20. The picture distinctly shows the vaporious, liquid and solidified areas. The area of the vapour capillaries 14 may include a plasma cloud 31, as can best be seen in Fig. 1.

Monitoring of the solidification front at the end of the melting zone 20 may be of importance for detection of defects occurring in connection with material solidification. For example, such defects may include surface roughness, weld convexity, holes or surface pores.

Such working defects occur during material solidification in the molten pool of the working process. They generally occur in the zone of direct interaction between the laser beam 2 and the workpiece 8 but normally the occurrence of said defects cannot be monitored in this zone. Insofar simultaneous monitoring of the melting zone 20 or specific picture sections of the melting zone 20 is of great importance.

In Fig. 2 various picture sections 23 to 30 are shown which are designed to monitor different process parameters of the working process. For example, the picture section 27 serves for the detection of defects occurring during weld preparation. In this case monitoring may be limited to the picture section 25. To allow rapid on-line monitoring only the pixels of the correspondingly selected areas are analysed by means of simple algorithms, such as the overall intensity of the area or the intensity difference between two pixels. With the aid of picture sections 26 and 28 the penetration depth of the laser beam can be monitored. Using the picture section 28 a considerable reduction of the amount of data can be carried out, for example by a row of pixels monitoring the vapour capillary 14 area transversely to the working direction. Using picture section 24 a positioning error as is shown below on the right in Fig. 4 can be detected.

By means of picture section 30 the surface topography of the solidified working zone downstream of the melting zone 20 can be monitored.

Picture section 23 can for example be used for weld tracking such that during the working process complicated contours can be tracked by scanning a predetermined track and correspondingly controlling the laser beam 2.

By means of picture section 29 which may be congruent with the picture section 28 but may also extend at an angle to picture section 28 the focal position of the laser beam can be monitored. For this purpose a narrow picture section extending transversely through the vapour capillaries 14 is selected.

Fig. 3 shows four different focal positions, and above the graphical representation the measuring signals are shown over the length of picture section 29. The first derivation of the measuring signal values is used for evaluating the focal position, that is the rate of change in the light intensity along picture section 29. The picture on the right side in Fig. 3 shows the optimum focal position which is characterized by two pronounced maximum values. In this connection reaching of a maximum value is monitored.

Fig. 4 shows four applications of the process described. The picture at the upper left in Fig. 4 shows the correct position of the two workpieces 8,9 to be welded with a third heat-sensitive part 11 being arranged below the second workpiece 9. In this case it is of importance that the penetration depth of the laser light beam 2 is exactly monitored.

The picture at the upper right in Fig. 4 shows a defect which occurred during weld preparation, i. e. the workpieces 8 and 9 to be joined with each other extend at an angle  $\alpha$  to the axis of the laser light beam 2. In this case monitoring of the focal position helps to easily detect whether the focal position has changed and thus the workpieces 8,9 have been incorrectly clamped.

The picture below on the left in Fig. 4 shows an undesired offset between the first workpiece 8 and the second workpiece 9 such that undesired full penetration welding may occur in the working zone. Such a working defect can for example be detected with picture section 27.

The picture below on the right in Fig. 4 shows a working defect, namely the laser light beam erroneously touching the second workpiece 9. Such a working defect can be detected via picture section 24 shown in Fig. 2.

Although preferred embodiments of the invention have been specifically illustrated and described herein, it is to be understood that minor variations may be made in the device and method without departing from the spirit and scope of the invention, as defined in the appended claims.

## CLAIMS

What is claimed is:

1. Method for measuring process parameters of a material working process using a high energy beam (2), in particular a laser beam, focused onto a working zone of a workpiece (8) by measuring with the aid of an optical sensor (10) the light intensity coaxially to the high energy radiation in the working zone in the area of vapour capillaries (14) produced by the high energy beam (2), the optical sensor (10) sensing a picture field and transmitting the measuring signals to an evaluation means (18),

wherein an optical sensor (10) having a dynamic range of more than 70 dB is used, and

measuring signals of sections of the image field showing the area of the vapour capillaries (14) and at least the area of the melting zone (20) surrounding the vapour capillaries (14) are simultaneously transmitted to the evaluation means (18).

2. Method according to claim 1 wherein in the picture field sensed by the optical sensor (10) different picture sections (24 to 29) are freely selectable and exclusively the measuring signals of these picture sections are used for simultaneous determination of different process parameters to be monitored.
3. Method according to claim 2 wherein the measuring signals of picture sections (27) showing the area of the melting zone (20) in front of or at the side of the vapour capillaries (14) are used for detecting defects occurring during weld preparation.

4. Method according to claim 2 wherein the measuring signals of a picture section (23) showing the melting zone (20) upstream of the working zone, as seen in the working direction, or the border area upstream of the melting zone (20) are used for measuring the weld location and for controlling the laser position or the workpiece position.
5. Method according to claim 1 wherein the penetration depth of the high energy beam (2) is determined on the basis of a reduced number of pixels of a picture section (28) showing the center of the vapour capillaries (14).
6. Method according to claim 2 wherein the measuring signals of a picture section (30) taken in the melting zone (20) downstream of the vapour capillaries (14), as seen in the working direction, and/or downstream of the melting zone (20), as seen in the working direction, are used for measuring the surface topography of the workpiece (8) to be subjected to the working process.
7. Method according to claim 2 wherein the measuring data of the different picture sections (23 to 30) are subjected to data reduction.
8. Method according to claim 1 wherein light of certain wavelengths in the beam path to the optical sensor (10) is filtered.
9. Method according to claim 1 wherein a CMOS camera is used as optical sensor (10).
10. Method according to claim 1 wherein by measuring the light intensity in the vapour capillaries (14) capillary parameters and by measuring the light intensity at at least one selected place of the melting zone (20) molten pool parameters are simultaneously determined, with control of the working process being carried out as a function of the determined capillary parameters and the determined molten pool parameters.

11. Method according to claim 1 wherein an optical sensor (10) having a dynamic range of more than 100 dB is used.
12. Method according to claim 1 wherein the focal position of the high energy beam (2) is determined by measuring the change in light intensity in a linear or rectangular picture section (29) extending through the vapour capillaries (14) and the neighboring melting zones (20).
13. Method according to claim 1 wherein the measuring signals of selected pixels are used for monitoring or process control purposes.

14. Device for measuring process parameters of a material working process comprising a means for producing a high energy beam (2), e. g. a laser beam, a focusing means (6) for focusing the high energy beam (2) onto a working zone of a workpiece (8), and an optical sensor (10) for measuring the light intensity of the vapour capillaries (14) produced in the working zone, the sensor (10) being focused coaxially to the direction of the high energy beam (2) onto the working zone of the workpiece (8), and an evaluation means (18) for evaluating the measuring signals of the scanned picture field supplied by the optical sensor (10),

wherein the optical sensor (10) has a dynamic range of more than 70 dB and transmits to the evaluation means (18) measuring signals from the area of the vapour capillaries (14) and at least an area of the melting zone (20) surrounding the vapour capillaries (14).

15. Device according to claim 14 wherein the evaluation means (18) receives only measuring signals of picture sections of the picture field covering, in addition to the area of the vapour capillaries (14), at least an area of the melting zone (20) surrounding the vapour capillaries (14).

16. Device according to claim 14 wherein the optical sensor (10) is a CMOS camera.
17. Device according to claim 14 wherein the evaluation means (18) evaluates the picture signals of a plurality of different picture sections (24 to 30) of the picture field scanned by the sensor (10) with regard to pre-determined process parameters.
18. Device according to claim 14 wherein near the vapour capillaries (14) the evaluation means (18) senses, for the purpose of measuring the penetration depth of the high energy beam (2), a predetermined reduced number of pixels showing the area of the high energy beam (2).
19. Device according to claim 17 wherein the evaluation means (18) evaluates the measuring signals of picture sections (24,27) showing the area of the melting zone (20) downstream of and at the side of the vapour capillaries (14), as seen in the working direction, for the purpose of detecting defects occurring during weld preparation.
20. Device according to claim 17 wherein the evaluation means (18) evaluates the measuring signals of picture sections taken in the melting zone (20) downstream of the vapour capillaries (14), as seen in the working direction, or downstream of the melting zone (20), as seen in the working direction, for the purpose of measuring the surface topography.
21. Device according to claim 17 wherein the evaluation means (18) evaluates the measuring signals of a picture section (29) extending linearly or rectangularly through the vapour capillaries (14) and the neighboring melting zone (20) for determining the focal position of the high energy beam (2).

22. Device according to claim 14 wherein a filter (15) is arranged in the beam path to the optical sensor (10) by means of which filter (15) specific wavelengths of the light received can be blocked.

00607 09980,60



## ABSTRACT OF THE DISCLOSURE

For a method for measuring process parameters of a material working process using a high energy beam (2), in particular a laser beam, focused onto a working zone of a workpiece (8), by measuring coaxially to the high energy radiation in the working zone the light intensity in the area of vapour capillaries (14) produced by the high energy beam (2) by means of an optical sensor (10) scanning a picture field and supplying the resultant measuring signals to an evaluation means (18), an optical sensor (10) having a dynamic range of more than 70 dB is used, and the measuring signals of sections of the picture field showing the area of the vapour capillaries (14) and at least the area of the melting zone (20) surrounding the vapour capillaries (14) are simultaneously transmitted to the evaluation means (18).

09703650 140900

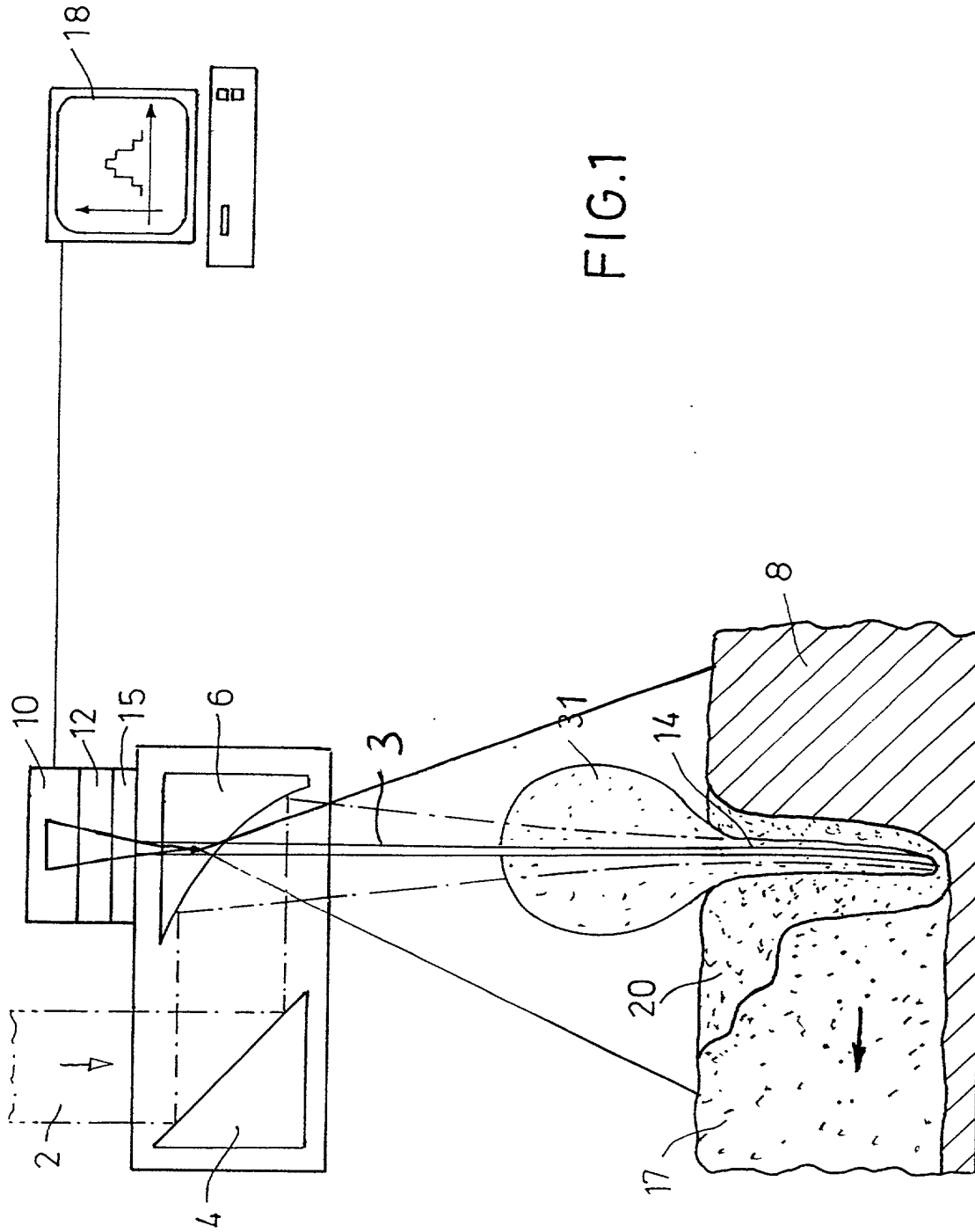


FIG.1

006077" 09980/60

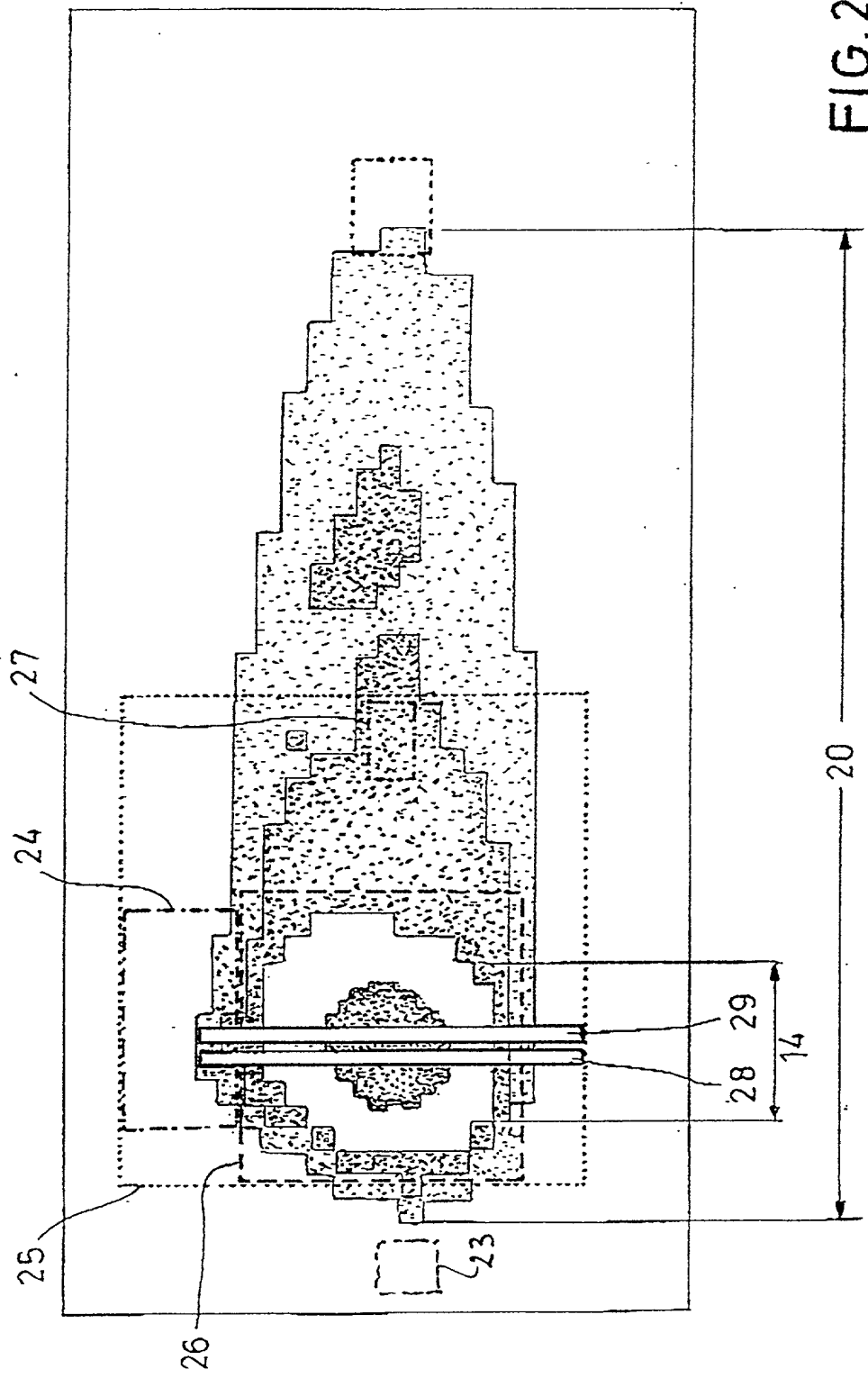


FIG. 2

-3/4-

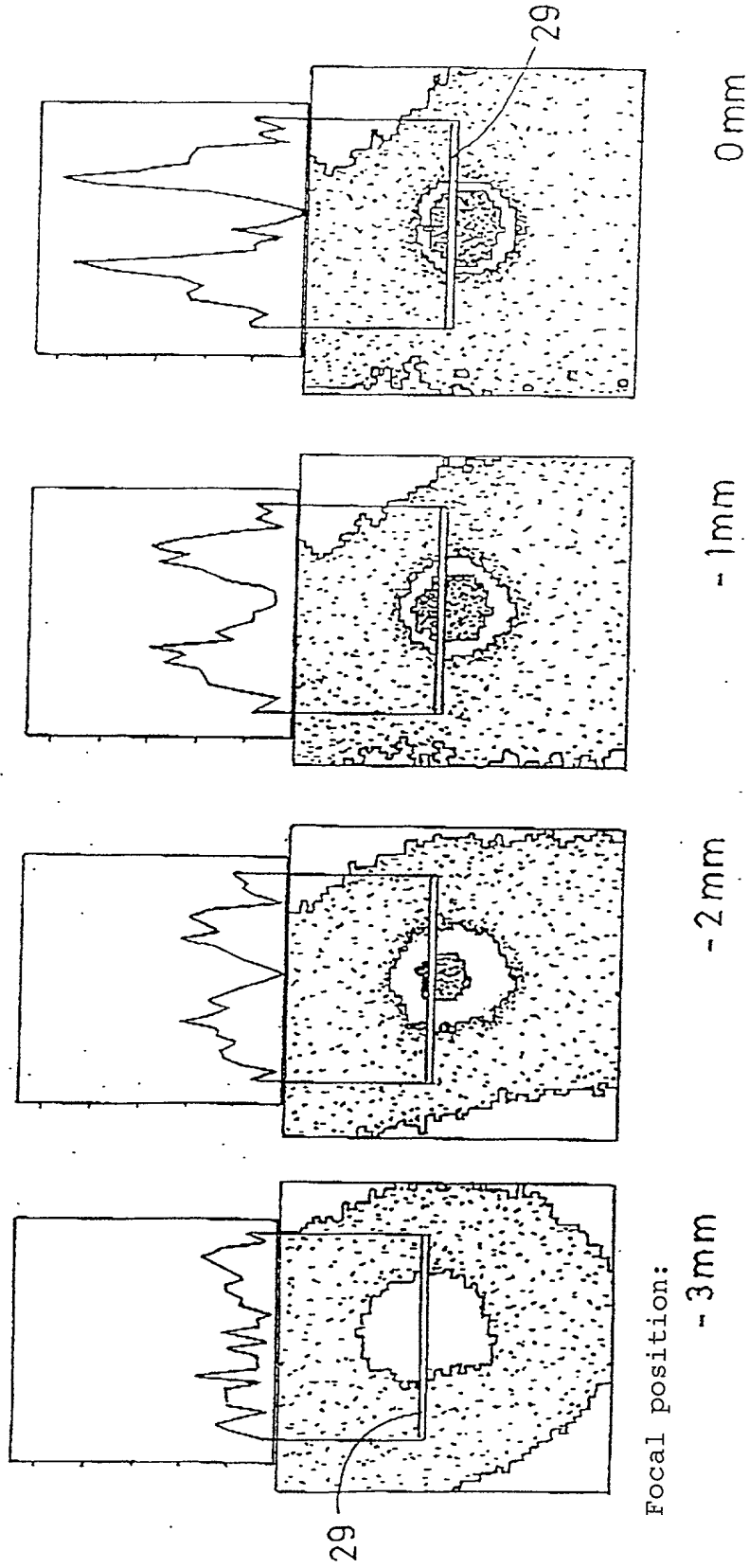


FIG.3

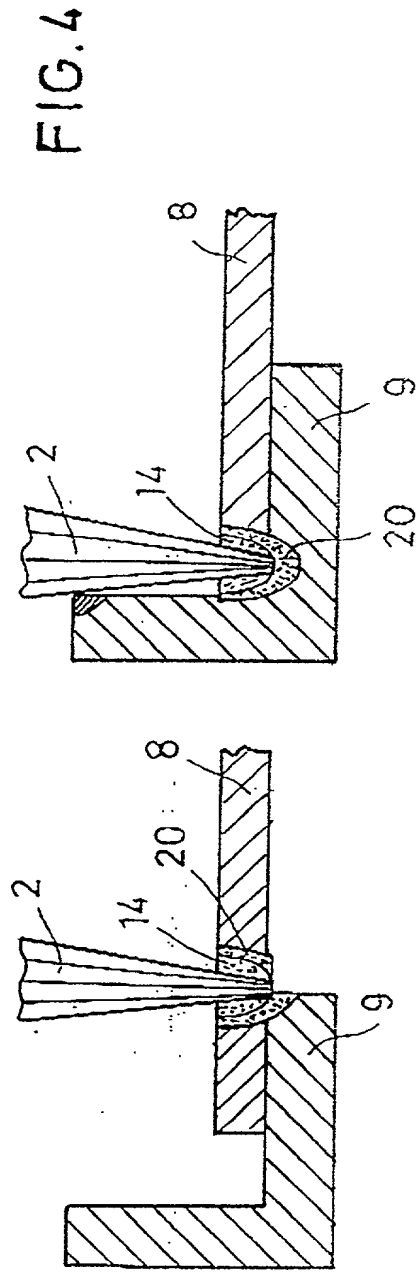
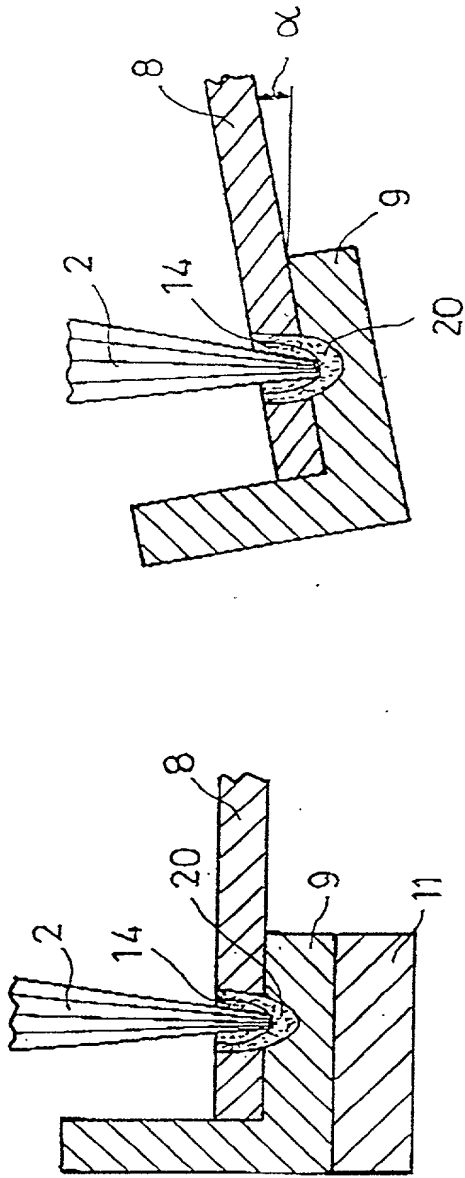


FIG.4

# COMBINED DECLARATION AND POWER OF ATTORNEY FOR PATENT AND DESIGN APPLICATIONS

ATTORNEY DOCKET NO.

PLEASE NOTE:  
YOU MUST  
COMPLETE THE  
FOLLOWING.

Insert Title

Check Box If  
Appropriate —  
For Use Without  
Specification  
Attached

As a below named inventor, I hereby declare that: my residence post office address and citizenship are as stated next to my name; that I verily believe that I am the original, first and sole inventor (if only one inventor is named below) or a joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: \*

Method and device for measuring process parameters of a material

working process

the specification of which is attached hereto unless one of the following boxes is checked;

- ☐ The Specification was filed on \_\_\_\_\_ and was assigned  
Serial No. \_\_\_\_\_ and was amended on \_\_\_\_\_  
☐ was filed as PCT international application number \_\_\_\_\_ on  
\_\_\_\_\_ and was amended under PCT Article 19 on \_\_\_\_\_

(if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I do not know and do not believe the same was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof, or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months (six months for designs) prior to this application, and that no application for patent or inventor's certificate on this invention has been filed in any country foreign to the United States of America prior to this application by me or my legal representatives or assigns, except as follows:

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below:

Prior Foreign Application(s)

Priority Claimed

99 122 600.2

Europe

November 12, 1999

☒ Yes ☐ No  
☐ Yes ☐ No  
☐ Yes ☐ No  
☐ Yes ☐ No  
☐ Yes ☐ No

(Number)

(Country)

(Month/Day/Year Filed)

(Number)

(Country)

(Month/Day/Year Filed)

(Number)

(Country)

(Month/Day/Year Filed)

(Number)

(Country)

(Month/Day/Year Filed)

(Number)

(Country)

(Month/Day/Year Filed)

All Foreign Applications, if any, for any Patent or Inventor's Certificate Filed More Than 12 Months (6 Months for Designs) Prior To The Filing Date of This Application:

Country

Application No.

Date of Filing (Month/Day/Year)

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)

(Filing Date)

(Status — patented, pending, abandoned)

(Application Serial No.)

(Filing Date)

(Status — patented, pending, abandoned)

I hereby appoint the following attorneys to prosecute this application and/or an international application based on this application and to transact all business in the Patent and Trademark Office connected therewith and in connection with the resulting patent based on instructions received from the entity who first sent the application papers to the attorneys identified below, unless the inventor(s) or assignee provides said attorneys with a written notice to the contrary:

**Vincent L. Ramik - Registration No. 20,663**

PLEASE NOTE  
YOU MUST  
COMPLETE THE  
FOLLOWING:

Send Correspondence to: **DILLER, RAMIK & WIGHT, P.C.**  
**Merrion Square Suite 101**  
**7345 McWhorter Place**  
**Annandale, Virginia 22003**  
**Telephone (703) 642-5705**

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of First or Sole  
Inventor:  
Insert Name of Inventor  
Insert Date This  
Document is Signed  
Insert Residence  
Insert Citizenship

Insert Post Office  
Address


Full Name of Second  
Inventor, if any:  
see above

Full Name of Third  
Inventor, if any:  
see above

Full Name of Fourth  
Inventor, if any:  
see above

Full Name of Fifth  
Inventor, if any:  
see above

\*Note: Must be completed  
- date this document is  
signed

GIVEN NAME Kluft		FAMILY NAME Werner		INVENTOR'S SIGNATURE 		DATE 06.11.00	
RESIDENCE (City, State & Country) 52078 Aachen, Germany						CITIZENSHIP German	
POST OFFICE ADDRESS (Complete Street Address including City, State & Country) Ellerstrasse 43, 52078 Aachen, Germany							
GIVEN NAME		FAMILY NAME		INVENTOR'S SIGNATURE		DATE	
RESIDENCE (City, State & Country)						CITIZENSHIP	
POST OFFICE ADDRESS (Complete Street Address including City, State & Country)							
GIVEN NAME		FAMILY NAME		INVENTOR'S SIGNATURE		DATE	
RESIDENCE (City, State & Country)						CITIZENSHIP	
POST OFFICE ADDRESS (Complete Street Address including City, State & Country)							
GIVEN NAME		FAMILY NAME		INVENTOR'S SIGNATURE		DATE	
RESIDENCE (City, State & Country)						CITIZENSHIP	
POST OFFICE ADDRESS (Complete Street Address including City, State & Country)							
GIVEN NAME		FAMILY NAME		INVENTOR'S SIGNATURE		DATE	
RESIDENCE (City, State & Country)						CITIZENSHIP	
POST OFFICE ADDRESS (Complete Street Address including City, State & Country)							